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For:	FUEL CELL	)
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**SUBSTITUTE SPECIFICATION IN CLEAN FORM UNDER 37 C.F.R. §1.125**

Commissioner of Patents  
Alexandria, Virginia 22313

Dear Sir:

The following substitute specification in clean form is hereby submitted with the above-referenced application. A marked up is also filed herewith. This substitute specification includes no new matter.

Dated this 16<sup>th</sup> day of October, 2006.

Respectfully submitted,

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# FUEL CELL

## BACKGROUND

### 1. The Field of the Invention

**[0001]** The present invention relates to fuel cells, and more particularly, to a fuel cell which can enhance an electricity generating performance.

### 2. The Relevant Technology

**[0002]** A fuel cell is an energy transformation device for the direct transformation of chemical energy of a fuel into an electrical energy by means of a chemical reaction. Different from a typical battery, a fuel cell can generate electricity continuously without recharging as long as fuel is fed into it. Recently, interest in the fuel cell has grown owing to its high energy efficiency and environmental friendly nature.

**[0003]** In general, a fuel cell is provided with two electrodes, i.e., an anode and a cathode arranged on opposite sides of an electrolyte. Typically, there is also an anode side separator on an outer side of the anode having a fuel passage and supporting the anode, and a cathode side separator on an outer side of the cathode having an air passage and supporting the cathode. An electro-chemical reaction of the fuel, takes place at the anode, and an electro-chemical reaction of oxygen, an oxidizer, takes place at the cathode. These electro-chemical reactions cause electric energy to be generated due to the migration of electrons taking place during the reactions.

**[0004]** Typical fuel cells may use a variety of fuels, such as LNG, LPG, methanol, gasoline, and the like. In general, the fuel is refined as hydrogen by passing it through a desulfurization process, a reforming reaction, and a hydrogen refining process at a fuel

reformer, and is used in a form of hydrogen gas. In some embodiments, fuel of a water solution state, for an example a solid state  $\text{BH}_4^-$  dissolved into a water solution state, is used as the fuel (Boro Hydride Fuel Cell). The Boro Hydride Fuel Cell (BFC) can dispense with the fuel reformer as the fuel of a water solution state is fed to the anode directly, and the reforming reaction takes place at the anode without the fuel reformer, thus simplifying the fuel cell system.

**[0005]** Typical fuel cells may also use a variety of electrolytes. For example, there are phosphoric fuel cells, molten carbonate fuel cells, alkaline fuel cells, solid oxide fuel cells, and polymer membrane fuel cells, and the like.

**[0006]** Referring to FIG. 1, a conventional fuel cell is illustrated. As illustrated in FIG 1, fuel is fed from a fuel tank 5 to a fuel cell 1 by a fuel pump 3, and air is fed to the fuel cell 1 by an air pump 7. The fuel cell 1 may be a unit cell or a stack of two or more unit cells.

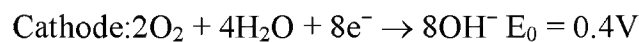
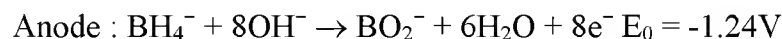
**[0007]** Referring now to FIGS 2 through 4, a specific example of another conventional fuel cell will be described. Note that each of the FIGS 2 to 4 illustrate a unit fuel cell. As illustrated in FIG 2 there is an anode 30 and a cathode 20 at opposite sides of an electrolyte 10. There are also separators 40 and 50 at an outer side of the anode 30 and the cathode 20, respectively. The anode 30 and the cathode 20 are porous and in general include Pt catalyst.

**[0008]** As mentioned, there is an anode side separator 50 at an outer side of the anode 30, and a cathode side separator 40 at an outer side of the cathode 20. As illustrated in FIGS 3 and 4, the separators 40 and 50 support the anode 30 and the cathode 20 respectively, and have passages 46, and 56 formed in general between barriers 44, and 54. Note that there can be a variety of passage forms. The separators 40,

and 50 serve to separate individual unit cells when unit cells are stacked. In addition, there can be separate electricity collecting plates at an outer side of the separators 40, and 50, respectively.

**[0009]** Typically, the electrolyte is an ion exchange membrane of a polymer material. A typical commercially available electrolyte membrane is Nafion membrane from Du Pont, which serves as a transfer body of hydrogen ions while at the same time preventing the oxygen from coming into contact with the hydrogen. Also the anode 30 and the cathode 20 are supporting bodies having a catalyst attached thereto of porous carbon resin or carbon cloth or other suitable materials. Further, the separators 40, and 50 are formed of dense carbon material, or Ni/SUS material or other suitable materials.

**[0010]** The action of the fuel cell will now be described as follows. The fuel and air fed to the fuel cell flow through the anode 30 and the cathode 20, and make the following chemical reaction:



**[0011]** Typically, in order to make the  $\text{BH}_4^-$  stable solution, a certain amount of Na is mixed, to cause a side reaction to generate hydrogen gas at the anode 30. That is, a reaction of  $2\text{H}_2\text{O} + \text{NaBH}_4 \rightarrow \text{NaBO}_2 + 4\text{H}_2$  takes place at the anode 30.

**[0012]** Accordingly, improvement of the electric generating capacity and performance of the fuel cell are desirable while the size of the fuel cell is kept as it is. This is because as the size of a fuel cell becomes larger for obtaining a desired electric generating capacity and performance, it becomes less convenient to use.

**[0013]** Consequently, there have been many suggestions for improving the capacity and performance of a fuel cell. For example, Japanese Laid Open Patent No. H10-228913 discloses the partial gold plating of electrodes and separators to reduce contact resistances between the electrodes and the separators, thus improving the performance of the fuel cell. However, this approach has proven effective in only a limited number of circumstances, leaving a need in the art for a fuel cell having a better electric generating performance.

## BRIEF SUMMARY

**[0014]** Accordingly, the principles of the present invention are directed toward providing a fuel cell that can improve electric generating capacity and performance without increasing a size of the fuel cell.

**[0015]** One embodiment herein described discloses a fuel cell. The fuel cell includes an electrolyte and an anode and a cathode at opposite sides of the electrolyte. The fuel cell further includes an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, and a medium layer between the cathode and the cathode side separator configured to at least partially prevent corrosion of the cathode side separator.

**[0016]** A further embodiment herein described also discloses a fuel cell. The fuel cell includes an electrolyte and an anode and a cathode at opposite sides of the electrolyte. The fuel cell further includes an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, a porous supporting member between the cathode and the cathode side separator configured to at least partially support the cathode; and a supporting member medium layer between the cathode and the porous supporting member configured to at least partially prevent corrosion of the porous supporting member.

**[0017]** An additional embodiment herein described discloses a fuel cell. The fuel cell includes an electrolyte and an anode and a cathode at opposite sides of the electrolyte. The fuel cell further includes an anode side separator at an outer side of the anode, a cathode side separator at an outer side of the cathode, and a medium layer between the anode and the anode side separator configured to at least partially prevent corrosion of the anode side separator.

**[0018]** Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]** To further clarify the above and other advantages and features of the present invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

**[0020]** FIG. 1 illustrates a block diagram of a prior art fuel cell system;

**[0021]** FIG. 2 illustrates a disassembled perspective view of a prior art fuel cell, schematically;

**[0022]** FIG. 3 illustrates a plan view of one example of the cathode side separator in FIG. 2, schematically;

**[0023]** FIG. 4 illustrates a section of FIG. 2;

**[0024]** FIG. 5 illustrates a circuitry expression of a fuel cell;

**[0025]** FIG. 6 illustrates a graph of a voltage drop in the fuel cell of FIG 5;

**[0026]** FIG. 7 illustrates a section of a fuel cell in accordance with embodiments of the present invention, schematically;

**[0027]** FIG. 8 illustrates a graph showing a comparison of the electric generating capacity of the fuel cells of the present invention and the prior art;

**[0028]** FIG. 9 illustrates another graph showing a comparison of the electric generating capacity of the fuel cells of the present invention and the prior art; and

**[0029]** FIG. 10 illustrates a section of a fuel cell in accordance with other embodiments of the present invention, schematically.

## DETAILED DESCRIPTION

**[0030]** Reference will now be made in detail to the embodiments of the present invention disclosed herein, examples of which are illustrated in the accompanying drawings. In describing the embodiments disclosed herein, parts identical to the parts of the prior art fuel cell will be given the same names and reference symbols, and a detailed description of such elements will be omitted.

**[0031]** An example embodiment of the fuel cell of the present invention will be first be described with reference to FIG. 7. As illustrated in FIG 7, the example embodiment fuel cell includes an electrolyte 10, an anode 30, a cathode 20, an anode side separator 50, and a cathode side separator 40. Of course, when the unit fuel cell of FIG 7 is staked in a stack of unit fuel cells, the cathode side separator 40 of the unit fuel cell will touch an anode side separator of a different unit cell. In like manner, the anode side separator 50 will touch a cathode side separator of a different unit cell.

**[0032]** Typically the prevention of corrosion of the side separators, particularly the cathode side separator 40, allows for improved performance of the fuel cell. For example, as shown in FIG. 5, when the fuel cell generates electricity, ions move from the anode → the electrolyte → the cathode, and electrons move from the anode (r2) → the anode side separator (r1) → the cathode side separator (r4) → the cathode (r3), wherein all the moving paths of the electrons act as a kind of inner resistance. As shown in FIG. 6, if the inner resistance increases, the performance of the fuel cell drops according to the I-V characteristics of the fuel cell.

**[0033]** During operation of the fuel cell, corrosion typically takes place at the cathode side separator 40, which may be a cause of the increase of the inner resistance discussed above. However, conventional solutions to increasing fuel cell performance

have failed to properly address prevention of corrosion of the side separator 40 as one important factor for improving the performance of the fuel cell. For example, as described in the prior art, Japanese Laid Open Patent No. H10-228913 suggests partial gold plating at contact surfaces of electrodes and side separators to reduce contact resistances between the electrodes and the side separators and the use of stainless steel as a material of the side separators for prevention of corrosion. However, it is often difficult to avoid the corrosion effectively by using a side separator of metal. It is often the case that positive corrosion prevention is more effective than prevention of simple contact resistance for improving the performance of the fuel cell.

**[0034]** Accordingly, the principles of the present invention are directed towards preventing corrosion of the side separators for improving performance of the fuel cell. Although any methods that can effectively prevent corrosion of the cathode side separator is applicable, an example method will be described in the following example embodiment. Note that the example embodiment to follow is for illustration only and is not meant to limit the scope of other embodiments disclosed herein or to limit the scope of the appended claims. As mentioned previously, it will be appreciated that other methods that prevent corrosion of the side separators are also contemplated.

**[0035]** Referring again to FIG. 7, a medium layer 300 is shown between the cathode side separator 40 and the cathode 20 configured for prevention of corrosion of the cathode side separator 40. Although the medium layer 300 may be provided separately, it is preferable in some embodiments that the medium layer 300 be a coated layer of a material selected from materials having ionization tendencies similar to the cathode 20. Having similar ionization tendencies between medium material 300 and cathode 20 helps to prevent the corrosion at the cathode side separator 40 that may be caused by a

voltage difference due to differences of ionization tendencies of the cathode 20 and the cathode side separator 40.

**[0036]** As illustrated in FIG 7, the coated layer 300 on the cathode side separator 40 may be applied to a contact surface 302 of the cathode 20, a bottom surface 304 of the passages 46, and a wall surface 306 of the passages 46.

**[0037]** Since the cathode 20 often includes a Pt catalyst, the coated layer 300 may be formed of Pt, gold, copper, nickel, and the like, without limitation, having an ionization tendency the same or similar to Pt. In some embodiments it is preferable that the coated layer 300 be formed of gold, due to production costs ,production processes and the like.

**[0038]** In addition, corrosion may also take place at the anode side separator 50. Accordingly, a medium layer (not shown), for example similar or the same as the coated layer 300, may also be applied to the anode side separator 50 for prevention of corrosion of the anode side separator 50. Of course, in such embodiment, it is also preferable that the coated layer is formed of a material that shows little or no voltage differences from the anode 30.

**[0039]** Referring now to FIG. 8, an illustration of a graph showing a comparison of the electric generating capacity of the fuel cells of the present invention and the prior art is shown. In this case, a fuel cell has a cathode side separator 40 that includes Pt. The plot of FIG 8 shows that when the fuel cell, as in the present invention, further includes a gold coated layer (i.e., medium layer 300), the fuel cell shows approx. 50% improvement in electric generating performance as compared to when the fuel cell, as in the prior art, does not include the coated layer 300, if other conditions are the same. Since results of experiments for various kinds of fuel cells show similar trends, only one

result of the experiment is shown in FIG. 8 for convenience. Similar performance results may also be seen in FIG 9.

**[0040]** Turning to FIG. 10, an alternative embodiment of a fuel cell is illustrated. As illustrated, there may be a porous supporting member 100, for example, a mesh member, between the cathode 20 and the cathode side separator 40. The supporting member 100 is also susceptible to corrosion. To help prevent such corrosion, a gold plating may be applied to the supporting member 100 to reduce the inner resistance, which allows a performance improvement as explained above. In some embodiments, the performance improvements are greater if the cathode side separator 40 is coated with gold.

**[0041]** In addition, there may also be an anode supporting member 80 between the anode 30, and the anode side separator 50. Supporting member 80 may also be susceptible to corrosion. Accordingly, the same principles of corrosion prevention described in relation to supporting member 100 are applicable to the anode supporting member 80. Of course, the principles of above embodiments are not limited to a fuel cell of the BFC type, but are applicable to other fuel cells, too. The effective prevention of corrosion at the cathode side separator and/or the anode side separator helps to reduce an inner resistance of the fuel cell to improve electric generating performance and capacity.